FINAL TECHNICAL REPORT
ONR GRANT #N00014-90-J-1050

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Modeling of Coastal Ocean Flow Fields

In Allen, Samelson, and Newberger (1991), we demonstrate the existence of a chaotic invariant set of solutions of an idealized model for wind-forced quasi-geostrophic flow over a continental margin with variable bottom topography. For weak (constant plus time-periodic) forcing and weak friction, we apply a recent extension (Wiggins and Holmes, 1987) of the method of Melnikov (1963) to test for the existence of transverse homoclinic orbits in the model. We find that in the presence of constant positive wind stress τ_0 (equatorward on eastern ocean boundaries) chaotic solutions exist when the ratio of an oscillating wind stress τ_1 to the bottom friction parameter is above a critical value that depends on τ_0/r and the bottom topographic height.

Research was continued on the development of intermediate models for the study of subinertial frequency mesoscale motion in stratified shelf, slope, and adjacent interior ocean flow fields. Intermediate models are derived under the assumption that the Rossby number ϵ is small. They filter out high frequency gravity-inertial waves while still being capable of representing flow over O(1) topographic variations typical of the continental slope. Our recent research on intermediate models applied to the shallow-water equations has been extended to the continuously stratified case, where a new balance equation model (BEM) that is based on momentum equations and possesses global invariants of both energy and potential enstrophy has been formulated (Allen, 1991). In addition, a new set of iterated geostrophic (IG) intermediate models has been formulated (Allen, 1993). The IG models utilize the pressure field as the basic variable, are capable of providing solutions of formally increasing accuracy in powers of ϵ in a systematic manner, and are straightforward to solve numerically. In Allen and Newberger (1993), several stratified intermediate models, including two new IG models (IG2 and IG3), the geostrophic momentum (GM) approximation, the balance equations (BE), the balance equations based on momentum equations (BEM), and the quasi-geostrophic (QG) approximation, have been applied to initial-value problems for unstable baroclinic jet flow fields typical of the coastal transition zone. The accuracies of the models have been assessed by comparison to solutions from an explicit primitive equation model (PE). A semi-implicit primitive equation model (PESI) used with large time steps equal to those of the intermediate models, was also included. The results show that BE, IG3, BEM, and PESI give extremely accurate approximate solutions to PE over a wide range of Rossby numbers, from moderately small to O(1). In contrast, the GM and QG models give quantitatively inaccurate solutions even at moderately small Rossby number. Overall, the results provide considerable encouragement for the potential use of intermediate models for coastal flow problems.

Mar 95

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LIST OF PUBLICATIONS

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Allen, J. S., R. M. Samelson, and P. A. Newberger, 1991; Chaos in a model of forced quasigeostrophic flow over topography: An application of Melnikov's method. *J. Fluid Mech.*, **226**, 511-547.

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